PROTECT FROZEN FOODS
FROM
TEMPERATURE DAMAGE

Despite the great commercial success of frozen foods, they face a constant danger--as well as a great opportunity. That danger is exposure to high temperature. The opportunity is preservation of a still greater portion of their original quality by rigid avoidance of all temperature damage. To convince the many thousands who handle frozen foods that temperature damage can and does take its toll, here are facts on kinds of quality loss--and their rates at various temperatures--from the Time-Temperature-Tolerance Project in USDA's Western Regional Research Laboratory in Albany, California.

Western Utilization Research and Development Division
Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

THE TIME-TEMPERATURE-TOLERANCE PROJECT

Industries who make, transport, store, or sell frozen foods try constantly to avoid temperature damage. This undertaking is a complex, difficult, nationwide effort that involves all the steps in handling--as well as equipment and management.

Several years ago, industrial leaders proposed research that would involve collection of samples from packers in major producing areas during several seasons. It involved testing for losses of quality at various temperatures during various periods, representing mild to severe conditions known to be causing inestimable losses.

The Western Utilization Research and Development Division of the U.S. Department of Agriculture's Agricultural Research Service undertook the project and now, after construction of special facilities and several years of work on samples, is presenting results to all who are interested.

Project workers have collected over 50,000 samples from commercial plants in major producing areas and their work on fruits and on concentrated orange juice is complete. Studies on vegetables, poultry products, and prepared foods are well along.

Practical information is available and as much as possible is summarized in this report. Emphasis is placed here on needs of those who ship, store, sell, and deliver frozen foods. Technical reports are valuable especially to those engaged in the development of equipment and packaging and in the technology of frozen-food manufacture.

Practical information includes more than the simple fact that zero is a safe temperature and must be consistently held if original quality is to be protected. Better frozen-food handling requires proof that damage is developing even though it is not easily apparent. Practical knowledge includes <u>factors</u> in quality, <u>kinds</u> of damage, and <u>rates</u> of each kind under various temperature conditions.

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QUALITY AND TEMPERATURE

The frozen-food industries have established high standards and new concepts of quality, which are important in merchandising. They are basic reasons for consumers' purchases--the real reasons for the success of frozen foods.

Quality is complex. It includes color, flavor, texture, attractive appearance, nutritive values. In the Time-Temperature-Tolerance Project and other frozen-food research, chemical analyses are used for vitamins and other compounds, light-measuring colorimeters and spectrophotometers for color, force-measuring instruments for tenderness, trained human tasters for flavor and appearance. Such methods supply reliable measurements.

A familiar and useful example of quality and its decline is supplied by fresh foods--and freshly prepared foods. They age quickly in ordinary surroundings--lose color, flavor, texture, nutritive values--even before they spoil from action of bacteria and molds. This loss of prime quality can be simply described as aging. Essentially the same changes occur in frozen foods if temperature is not low enough.

Erroneous assumption No. 1 is this: That a cold and hard package of frozen food is adequately protected against loss of prime quality. All the chemical reactions that result in loss of quality accelerate as temperatures rise from 0°F or lower level. At 15° these changes occur several times as fast as at 0°--and at 25° to 30° several times as fast as at 15°F. Coldness and hardness do not assure protection.

Erroneous assumption No. 2 is this: That lowering temperature down to zero or lower corrects temperature damage. As temperature of frozen foods rises or falls, losses of top quality move fast or slowly. They never move in reverse. No one can make old foods young again.

Erroneous assumption No. 3 is this: That temperature damage is not retained over long periods. Even slight changes in color, flavor, or other quality factors early in the commercial life of a frozen food remain regardless of excellent handling later.

IMPORTANT GENERAL FACTS: Decline from topmost quality proceeds by numerous processes whose initial stages are not detectable on casual examination. These changes are barely active at zero or lower but as temperature rises these rates increase rapidly--doubling several times in the range up to 25°F. Severe damage results from accumulations of mild damage, as well as from single severe exposures.

TEMPERATURE DAMAGE IN FROZEN FOODS

Frozen Fruits

Frozen fruits are damaged in several ways, and certain types of damage become conspicuous early. Changes in color and appearance are important and easily detected. Less easily detected changes also occur at the same time.

Examples are dark-brown peach slides, discolored strawberries, raspberries with color bled into the sirup, dull-brown cherries with toughened skins. Quality changes may begin even before freezing and develop a little at a time with minor mishandlings--or they may occur with brief severe exposure.

Of four retail-packed fruits investigated comprehensively, frozen peaches are most quickly and conspicuously damaged. Brown slices can cause consumer complaint, and they may become apparent after total exposures of 24 hours or less time at 30°, 100 to 150 hours at 20°, 60 days at 10°, or 2 years or longer at 0°F.

Strawberries undergo flavor changes that become easily detectable within totals of 24 to 48 hours at 30°, 6 to 12 days at 20°, or about 3 months at 10°--but will lose little top quality in well over a year at steady 0°F. The discoloration and loss of vitamin C develop simultaneously. Flavor change is early evidence of quality loss.

Frozen raspberries reveal temperature damage less quickly than other fruits but tend to lose color from berries to sirup at fairly rapid rates. This change is not accompanied by drastic change in flavor but definitely indicates that the product is losing its fresh condition. Zero or lower supplies protection.

Fruits contain important amounts of vitamin C (ascorbic acid). Top-quality strawberries contain more than orange juice. Frozen peaches are frequently packed with added ascorbic acid to retard browning. Temperature abuse causes loss of this vitamin--and rate of loss is related to rates of other losses of quality factors.

The project has shown that cooperative industrial efforts to avoid temperature damage can be aided by the test for ascorbic acid in strawberries. Analyses measure not only vitamin remaining but also the chemical products of its destruction; therefore the original and the lost percentages can be estimated. For raspberries, flow of color from berries to sirup reveals temperature experience. Similar methods can be used with other fruits.

Those who handle frozen fruits, and also other products, may well remember this fact: Held a day at 20 °F., products may not show damage--for example, peaches may not turn brown. The next handler, however, may expose the product to minor temperature hazards and find that the damage is conspicuous, and it can't be corrected.

Frozen Concentrated Orange Juice

Several factors are especially significant in the handling of frozen concentrated orange juice. It is a major outlet for the nation's orange crop and a major product in the frozen food industry. It is widely consumed for its vitamin C (ascorbic acid) and other nutritive values. Its color, flavor, and the stability of its cloud are quality factors to which millions of consumers are highly sensitive.

The sealed metal containers protect against access of air and thus limit oxidative reactions, but they also allow thawing that would seriously damage most other containers. The product may seem to be adequately protected, when actually it is undergoing changes that cause consumers to regard it as a low-grade rather than a high-grade product.

Tendency to develop instability of cloud (that is, to separate when mixed with water) has led to an industry-wide practice of mild heating in the processing of this product. This practice has improved stability but temperature damage remains as a major problem. Tendency to lose stability of cloud was observed in all samples, but in varying degrees at temperatures above 0 °F. Over long periods at 0° the products gradually lose ability to withstand temperature damage.

In the project some but not all heat-treated samples retained stable cloud in an initial test of 5 days at 10° followed by a steady rise to 40° with immediate refreezing to 0 °F. All unheated samples failed in this single test. All the heat-treated samples that survived the first test failed in a second similar test later.

In the lower range of exposures for longer times, most unheated samples were able to retain cloud when exposures over a year added up to no more than 24 days at 10 °F. Heated samples generally withstood mistreatment twice as severe, but varied. Thus temperature damage accumulates and quickly exhausts the original stability of frozen concentrated orange juice.

Undesirable change in flavor was found to be a slower process than cloud loss, and loss of vitamin C still slower. These losses, however, do proceed faster as temperature rises and eventually add severely to the total quality losses in frozen concentrated orange juice.

Frozen Vegetables

Temperature-tolerance studies on vegetables are incomplete but present data supply general descriptions of quality loss and measurements of rates. Temperature-damaged green snap beans, for example, first darken and later turn olive drab and eventually brown. Peas turn grayish-green and then yellowish as green color is lost.

Trained judging panels are consistently able to detect a color change in beans held at 0°F. in about 3 months. They can do the same with peas at 0°F. in about 6 months. These observations indicate the comparative rates of color change in these two products. They do not evaluate the severity of damage; at zero steadily held, overall quality continues at a high level for at least 2 years.

The trained panel identifies the same change mentioned above in beans held at 10° after one month, after 10 days at 20°, and after about 3 days at 30°F. For peas the time periods are roughly double in each case.

Undesirable change in flavor of beans is detectable by the trained panel after about 3 times the periods required for detections of color change at the various temperatures listed above. Flavor change in peas is slightly more rapid. Thus for both vegetables, color changes more rapidly than flavor.

Losses of chlorophyll (green pigment) and of vitamin C are useful measures of loss of quality. In green beans chlorophyll is lost at the rate of about 7% per year at 0°F. At this rate high levels would be retained for several years. At 10°F., this rate of loss is about 7 times the rate at zero, at 20°, 20 times, and 30°F. 160 times as fast. Loss rates for vitamin C are similar.

The facts above emphasize the striking increases in rates as temperatures rise higher and higher above zero--and particularly as they reach temperature levels of 25°, 30°, and above. Long periods at lower temperature above 0°F.--without apparent softening--will result in the same sort of damage.

Frozen Poultry Products

Frozen poultry, like other products, changes undesirably in flavor and appearance with increasing rapidity as temperature rises in the range with which frozen food handlers are vitally concerned. Generally, turkeys are somewhat less stable than chickens. Commercial products, for various reasons, vary widely in stability. To protect all products adequately, however, 0°F. or lower should be maintained as consistently as possible.

Freezer burn from loss of moisture has been reduced by moisture-proof packaging, but another change in appearance--from light to red or darker color--can result from failure to control temperature. Light appearance results from rapid initial freezing and if the bird is held at 20°-25°F. for only 1 or 2 weeks, significant darkening develops--especially in young roaster-fryers and broilers.

Whole birds are more stable than cut-up birds in equivalent packages. Flavor change reaches detectability in well-packaged cut-up fryers in 9 or 10 months at 10° and 5 or 6 months at 20°F., but with less effective packaging these periods may be reduced to 1 month at 20°, 3 months at 10°, and not over 6 months at 0°F.

Fluctuation of temperature causes slightly more frost inside packages than in packages of comparable birds held steadily at the highest temperature of the fluctuation. This difference is not important because total moisture accumulation in a tight, moisture-resistant package is so small that appearance of the thawed bird is unaffected.

Prepared Frozen Foods

Products studied thus far are fried chicken, turkey dinners and pies, creamed chicken and turkey products, and sauces and gravies used in such products as a la king and custard and pudding desserts.

The flavor change first detected in cooked poultry meat is loss of "freshly cooked" flavor, which is followed eventually by staleness and and finally by distinct rancidity. At 20°F. flavor changes are detectable in fried chicken within less than 2 weeks, staleness or rancidity develops within 6 weeks to 3 months, and mold occurs on pies held 9 months. At 10°F. and lower, stability of flavor is greatly affected by exposure of the meat to air. For example, the sauce or gravy in pies protects the meat, and hence dinners, pies, creamed products and a la king are protected against serious flavor damage for as long as 6 to 12 months at 10°F. or lower. Fried chicken, however, suffers damage twice as quickly at these temperatures.

Curdling, separation of liquid, and loss of smoothness are undesirable changes that can develop in puddings, desserts and gravies after they are thawed. Such foods become much more defective in this respect when exposed to temperatures above 0°F. Research has revealed improvement from use of certain thickening agents (such as waxy rice flour) in their preparation, but even improved products are sensitive to temperature damage.

MEASURING TEMPERATURES

Improvement in handling of frozen foods depends to a large extent on wide dissemination of information such as that summarized here. Improved temperature protection means more excellent quality delivered from farms and freezing plants to consumers. Every industrial group bears a heavy responsibility. Each must guard against creeping, accumulating damage just as effectively as against sudden damage.

Improved handling means constant attention to product temperatures. Control of product temperatures in turn means measurements of temperature consistently, in the products themselves and in their environments. Frequent temperature measurement enables one to become "temperature minded" and to understand equipment performance as well as quality losses that develop in products.

As an aid to greater and more effective use of thermometers the Time-Temperature-Tolerance Project has included a study of product temperature measurement in cases of frozen foods without destruction of either carton or individual packages. The method simplifies the operation, reduces time required, and produces accurate results.

A metal, disk-type thermometer is used. With a razor knife a small opening is made in the carton wall to reveal where the corner package comes together with the next one. The thermometer stem is simply inserted about 3 inches in contact with both packages. The cut end of the carton opening is forced against the stem. About 5 minutes are required to obtain a reading that investigation has shown to be that of the product itself.

Center temperature in the carton can be taken similarly, and if it is higher than the corner temperature it is likely that the carton has been exposed to higher temperature recently. More detailed information is available on this study, and also on the entire project.

Thermometer readings are important. They measure not only degrees of protection but also rates at which quality is disappearing.

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